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The 1975 summer-fall plankton of in-
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THE 1975 SUMMER-FALL PLANKTON OF INSHORE

AND EMBAYMENT AREAS OF LAKE NIPIGON

by

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INTRODUCTION

During 1975, the Ontario Ministry of Natural Resources undertook a water quality assessment of Lake Nipigon in the vicinity of Ombabika Bay and Humbolt Bay to determine if turbidity in Ombabika Bay, thought to have been caused by diversion of the Ogoki River down the Jackfish River, was influencing the biomass and composition of plankton in the Bay. In this regard, the Ministry of Natural Resources requested the assistance of the Ministry of the Environment, Taxonomy and Technical Support Unit to analyze and interpret phytoplankton and zooplankton from several locations in the northwest portion of Lake Nipigon.

Historical information on the plankton of Lake Nipigon is scarce (Clemens et al, 1923; Bigelow, 1923; Mackay, 1951). Although no pre-diversion data on the plankton of Ombabika Bay were available from this study, adjacent and presumably non-affected embayment and inshore areas of Lake Nipigon were sampled for comparative purposes. Six sampling stations were established; three in Ombabika Bay, one outside the mouth of Ombabika Bay and two stations in Humbolt Bay (Figure 1) these sites were visited from ten to fifteen times between June 21 and October 2, 1975 during which time physical and chemical data were collected along with the plankton samples. Additionally, the data provide information on Lake Nipigon which will have historical value in assessing future changes in the limnology of the lake.

SECTION A - PHYTOPLANKTON

METHODS

Phytoplankton samples were collected, after determining the photic zone depth by means of a secchi disc, by using a length of tygon tubing to obtain a sample representative of the water column. These samples were preserved with lugol's iodine solution and shipped to the Ministry of the Environment laboratories in Toronto for analyses.

Phytoplankton samples were analyzed using the Utermöhl technique. Samples were concentrated by sedimentation and examined at 600 x magnification with inverted microscopes to facilitate the identification of the nanoplankton. A minimum of two hundred organisms were identified to the generic level and their measurements taken to determine biomass (expressed as mm^3/l). Enumeration and taxonomic analyses of phytoplankton samples were carried out by staff of the Taxonomy and Technical Support Unit, Ministry of the Environment.

RESULTS

Information on biomass values is summarized in Table 1 by station and by date. Phytoplankton levels ranged from a seasonal mean of $0.38 \text{ mm}^3/\text{l}$ at Station 4 to $0.75 \text{ mm}^3/\text{l}$ at Station 3. Changes in the season of development and composition of the major taxonomic groupings (i.e. Bacillariophyceae, Dinophyceae, Chlorophyceae, Cryptophyceae and Cyanophyceae) are presented in Figure A-1. Generally the Bacillariophyceae (diatoms) were the dominant groups while the Cryptophyceae and Cyanophyceae were the two sub-dominant groups present. It would appear that there was a slight seasonal shift from the cryptophytes in July to the blue-greens (Cyanophyceae) in August to the diatoms in August-September. At Stations 1, 2 and 3 inside Ombabika Bay the diatoms represented approximately 50% of the population with the cryptophytes and blue-greens making up the remaining amount in equal proportions. Outside Ombabika Bay, at Station 4 and at Stations 5 and 6 in Humbolt Bay the diatoms comprised approximately 56-60% of the biomass but the cryptophytes represented two-thirds of the remaining amount and the blue-greens represented one third.

The Cryptophyceae, Cryptomonas sp. and Rhodomonas sp. were present at all stations throughout the sampling period. Melosira was the dominant diatom at Stations 1, 2 and 3 with Tabellaria, Fragilaria and Stephanodiscus appearing

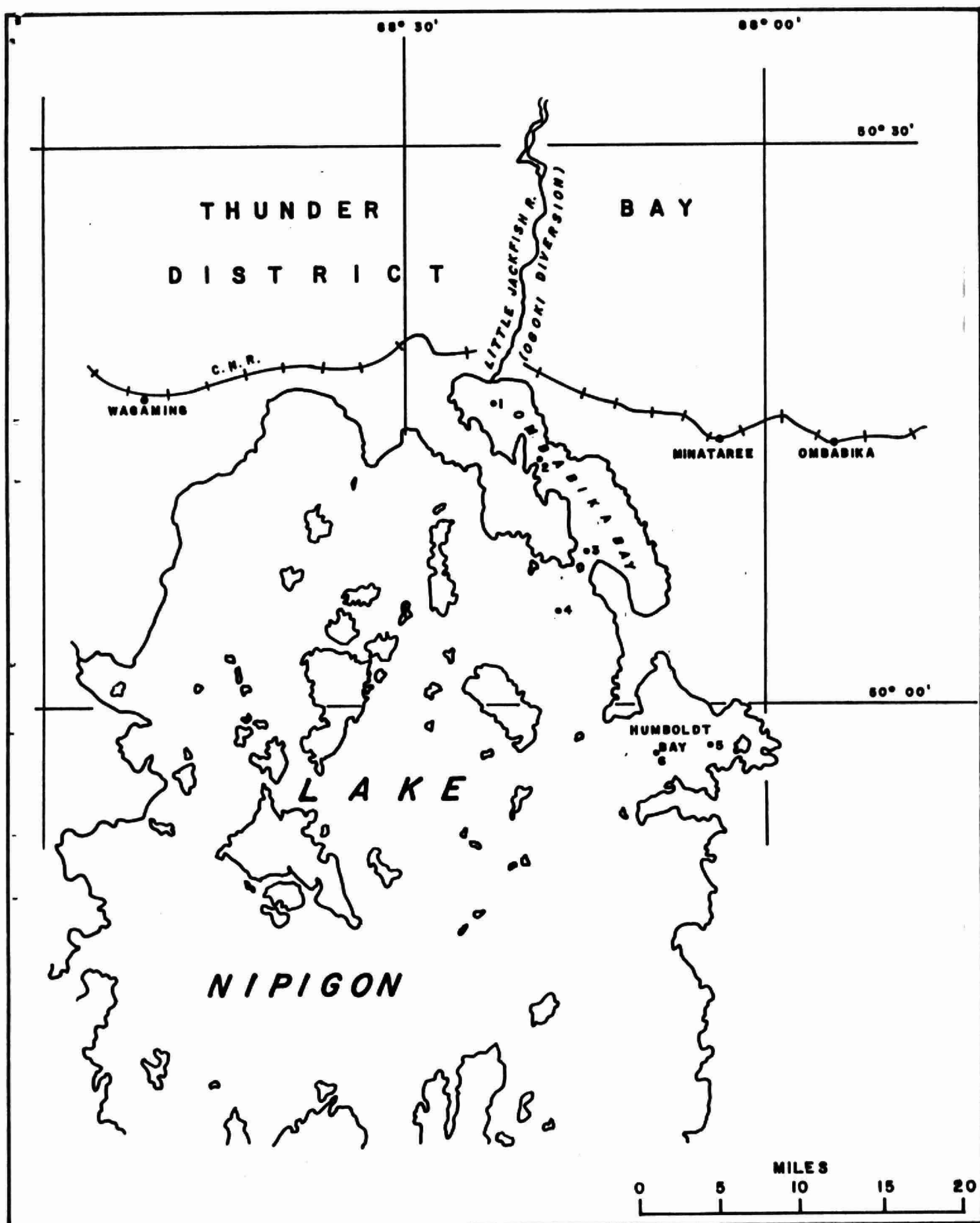


FIG. 1 LAKE NIPIGON, SHOWING LOCATIONS OF THE SIX PLANKTON SAMPLING STATIONS.

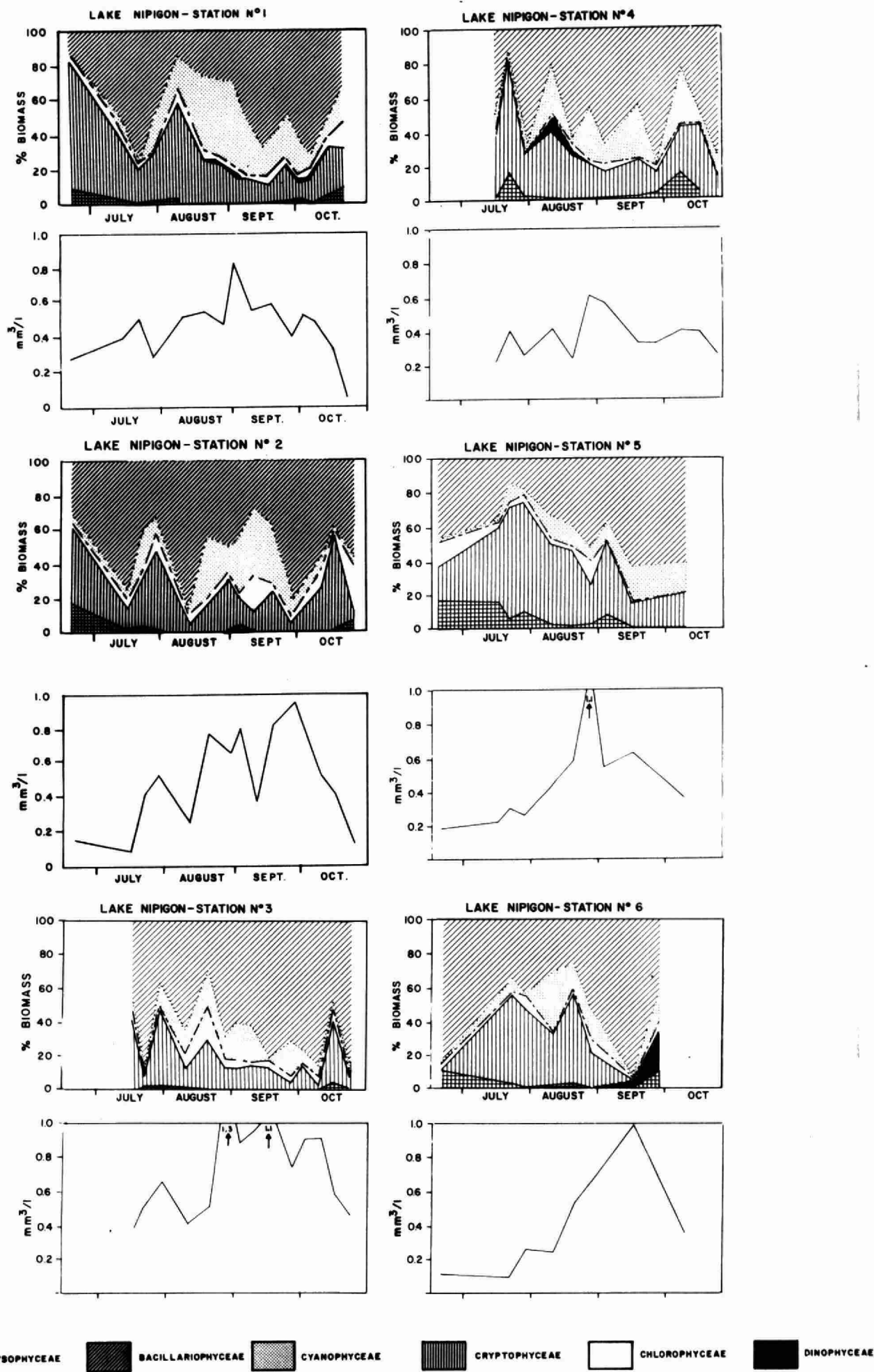


Figure A-1: Seasonal fluctuations of phytoplankton biomass (mm^3/l) and percent composition by algal group at six stations in Lake Nipigon, 1975.

as subdominant forms. At Stations 4, 5 and 6 Melosira was replaced by Stephanodiscus as the dominant form with Tabellaria, Fragilaria, Asterionella, Cyclotella and Rhizosolenia combining to form the sub-dominant genera. The Cyanophyceae, Anabaena and Aphanizomenon were the dominant blue-greens at all stations and reached their maximum levels in late August. However, levels of these two organisms were noticeably lower at Stations 4, 5 and 6 than at Station 1, 2 and 3. Oscillatoria appeared occasionally as a sub-dominant form.

Water clarity measured by means of a Secchi disc ranged from a low mean value of 1.6 metres at Station 3 to a high mean value of 4.8 metres at Station 6 (Table 2). Secchi disc values were lower at the three stations in Ombabika Bay with mean values of 2.2, 2.0 and 1.6 metres at Stations 1, 2 and 3 respectively. The mean values for Stations 4, 5 and 6 were 3.7, 4.2 and 4.8 metres respectively. The lowest Secchi disc reading was 1.0 metres at Station 3 on October 8, while the greatest reading (6.8 metres) was obtained at Station 5 on July 15th.

DISCUSSION

Phytoplankton biomass levels in Lake Nipigon are very low. While there are limited historical data (Bigelow, 1923 and MacKay, 1951) on phytoplankton biomass available for Lake Nipigon, recent papers (Vollenweider et al, 1974, Munawar et al, 1974 and Nicholls et al, 1975) provide comparable data from other large North American lakes (Table 3). Phytoplankton biomass ranging from 0.05 to 2.67 mm³/l in Lake Nipigon in 1975 with mean values ranging from 0.38 at Station 4 to 0.75 mm³/l at Station 3, are quite comparable to values for Lake Superior and Lake Huron (Table 3).

Statistical comparisons of the phytoplankton data were made for each station (Table 4) by using a test for evidence against equal means on paired data (Snedecor and Cochran, 1967). It may be seen from Table 4 that Station 3, located inside, had significantly higher algal biomass than Stations 1, 4, 5 and 6. Station 3, Ombabika Bay, had the highest mean biomass value and the lowest Secchi disc values. Secchi disc values inside Ombabika Bay were consistently low ranging from a mean of 1.6 metres at Station 3 to 2.2 metres at Station 1. At Stations 4, 5 and 6 the Secchi disc values were twice as great ranging from 3.7m at Station 4 to 4.8m at Station 6. It is quite possible that since the turbidity was fairly constant inside Ombabika Bay, the increase in phytoplankton at Station 3 was an advantageous response due to lack of competition by grazers. Part B of this report on zooplankton

at these stations in Lake Nipigon suggests that the numbers of zooplankters were greater outside Ombabika Bay. The grazing effect of these organisms could substantially reduce the phytoplankton population allowing for greater water clarity outside Ombabika Bay. While grazing may have an effect on phytoplankton levels in Ombabika Bay, water clarity in this area is poorer than would be expected from phytoplankton densities alone. A large part of the turbidity in the Bay is not attributable to plankton but more likely to resuspension of bottom materials and/or a silt load from the Jackfish river.

Table 1: Summary of Phytoplankton biomass at six stations, Lake Nipigon 1975. All values expressed as mm^3/l .

Date	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6	Mean
June 21	0.27	0.17	-	-	0.18	0.11	0.18
July 15	0.41	0.11	0.40	0.22	0.22	-	0.27
" 22	0.48	0.39	0.52	0.42	0.30	0.11	0.37
" 28	0.28	0.56	0.67	0.26	0.26	0.25	0.38
Aug. 11	0.51	2.67	0.43	0.43	0.44	0.24	0.79
" 20	0.52	0.79	0.52	0.24	0.59	0.55	0.54
" 27	0.48	0.64	1.35	0.62	1.18	0.67	0.82
Sept. 3	0.82	0.81	0.88	0.57	0.55	-	0.73
" 9	0.55	0.36	0.97	-	-	-	0.63
" 18	0.60	0.81	1.14	0.34	0.63	1.04	0.76
" 27	0.41	0.96	0.74	0.36	-	0.20	0.53
Oct. 2	0.52	-	0.89	-	-	-	0.71
" 8	0.50	0.50	0.90	0.41	0.36	-	0.53
" 16	0.33	0.43	0.58	0.40	-	-	0.44
" 23	0.05	0.15	0.47	0.27	-	-	0.24
Mean	0.45	0.67	0.75	0.38	0.47	0.40	

Table 2: Summary of Secchi Disc Values (in metres) at six locations in Lake Nipigon, 1975.

Date	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6
June 21	1.1	1.3	1.6	4.1	2.6	6.6
July 15	1.9	1.6	1.8	4.8	6.8	-
" 22	1.7	1.7	1.7	5.8	4.5	5.4
" 28	2.6	1.9	1.1	3.0	3.2	4.7
Aug. 11	2.2	2.1	2.2	3.2	3.8	3.9
" 20	3.1	2.3	1.7	4.4	4.8	5.5
" 27	2.0	2.2	1.9	4.0	3.2	4.0
Sept. 3	2.3	2.2	1.7	3.5	3.5	-
" 9	2.1	2.1	1.6	-	-	-
" 18	2.3	1.8	1.5	1.9	3.5	4.0
" 27	3.0	2.4	1.7	3.3	5.3	4.6
Oct. 2	1.3	-	1.5	-	-	-
" 8	2.3	2.1	1.0	3.2	5.0	3.9
" 16	2.2	1.8	1.5	3.2	-	-
" 23	2.3	2.1	1.7	3.7	-	-
Mean	2.2	2.0	1.6	3.7	4.2	4.8

Table 3: Comparative phytoplankton biomass* at several Great Lakes sampling locations and at six stations in Lake Nipigon.

Phytoplankton biomass (mm ³ /l)			
Source	Mean	Range	Reference
Lake Ontario			
Inshore	3.3	0.8 - 7.4	Vollenweider et al
Offshore	2.6	0.6 - 9.0	" (1974)
Lake Erie			
Western Basin	5.3	0.8 - 13.2	"
Eastern Basin	2.4	1.0 - 4.2	"
Lake Huron			
Mid-Lake	0.9	0.3 - 1.8	"
Saginaw Bay	8.3	1.6 - 17.3	"
Georgian Bay			
P1	6.25	1.75 - 31.5	Nicholls et al
BS	1.59	0.32 - 4.69	" (1975)
Lake Superior			
Nearshore Stations	0.2	0.05 - 0.60	Munawar et al
Offshore Station	0.1	0.03 - 0.20	" (1974)
Lake Nipigon			
Ombabika Bay Sta. 1	0.45	0.05 - 0.82	Present study
Sta. 2	0.67	0.15 - 2.67	" "
Sta. 3	0.74	0.40 - 1.35	" "
Outside Ombabika Bay			
Sta. 4	0.38	0.22 - 0.62	" "
Humbolt Bay			
Sta. 5	0.47	0.22 - 1.18	" "
Sta. 6	0.39	0.11 - 1.04	" "

* Lakes with phytoplankton densities less than 1 mm³/l are usually clear water lakes with transparencies (Secchi disc visibilities) greater than 5m. Phytoplankton densities greater than 20 mm /l are usually associated with very turbid waters having transparencies less than 1m.

Table 4: 1975 Phytoplankton data - Lake Nipigon - Test for evidence against equal means* - Significant Difference between means underlined.

Stations Compared	Means	Number of pairs	Value (P)
1/2	.442/.667	15	<.20
1/3	.461/.745	14	<u><.001</u>
1/4	.448/.378	12	<0.20
1/5	.485/.472	10	>0.50
1/6	.442/.394	8	>0.50
2/3	.705/.733	13	>0.50
2/4	.734/.378	12	<.10
2/5	.743/.472	10	<.40
2/6	.872/.394	8	<.20
3/4	.714/.378	12	<u><.001</u>
3/5	.754/.504	9	<u><.01</u>
3/6	.764/.434	7	<u><.025</u>
4/5	.389/.504	9	<.20
4/6	.379/.434	7	>.50
5/6	.566/.474	6	<.50

* If the probability value (P) is less than 0.05, Evidence exists against the hypothesis of equal means. If the probability is less than 0.01, strong evidence exists against equal means. No conclusions may be drawn from probabilities greater than 0.05.

SECTION B - ZOOPLANKTON

METHODS AND MATERIALS

Zooplankton samples were taken by means of a single vertical haul using an eighty micron mesh Wisconsin net with a mouth diameter of 13 cm. Six stations in Ombabika and Humbolt Bays and adjacent inshore area of Lake Nipigon were sampled from June 21 to October 23, 1975 (Fig. 1) with seven to fourteen sampling dates per station.

Zooplankton species were identified and enumerated by Dr. W. Geiling (Limnos Services, Lansdowne, Ontario) using Brooks (1957), Edmondson (1959) and Deevey and Deevey (1971) as taxonomic references.

The use of a single vertical net haul in the sampling method may have introduced some inaccuracy in determination of zooplankton density. Numerous authors (Hensen 1887; Herdmann 1921; Langford 1938; Tonnoli 1958; Stavn 1971) have found that zooplankton populations are usually patchy in their horizontal distribution, frequently causing vertical hauls taken a few metres apart to differ in zooplankton density by more than 100%. As a result, any single vertical haul becomes questionable as to its representation of the true zooplankton concentration. However, a larger sample size collected as a series of samples taken over several weeks (as done in this study) should result in an averaged density that is representative of the mean concentration in that time period.

Loss of filtering efficiency, a second source of inaccuracy of the Wisconsin net (UNESCO 1958) is caused by water resistance across the mesh of the net, which increases as the pores of the net become clogged with algae, detritus, etc. This results in a buildup of internal pressure, causing a certain percentage of water in the path of the net to be deflected around its edges. McNaught et al. (1975) and Rawson (1956) found net efficiencies to range between 15 and 70 percent.

As the data presented here were used primarily for comparative purposes ("disturbed" vs. "undisturbed" areas) and because no accurate net efficiency conversion factor exists for this study, the data were left uncorrected for net efficiency. As a result of the above probable inaccuracies, single, daily density values must be regarded as being approximate. Averaging these for a mean summer-fall density should reduce much of the error resulting from zooplankton patchiness, but the net efficiency bias remains.

Zooplankton densities, expressed in numbers (individuals) per cubic meter, were calculated by multiplying the theoretical volume of water filtered by the net - $(6.5 \text{ cm mouth opening radius})^2 \times 3.14 \times \text{height of water column sampled}$ - by the total count. Nauplii and copepodids (both immature copepod stages) were included in total copepod abundance estimates, but not in listings of adult dominance. Finally, statistical analysis of both densities and relative abundances were carried out, using the test for evidence against equal means (paired data) at a significance level of $p < 0.05$ (Snedecor and Cochran 1967).

RESULTS AND DISCUSSION

Zooplankton Density

In general, stations outside Ombabika Bay (No's 4, 5 and 6) had higher mean zooplankton concentrations, with Station 5 recording the maximum mean density (Table 1). At Station 4, zooplankton density was significantly ($p < 0.05$) greater than at all stations within Ombabika Bay, despite the variance introduced by its greater numerical fluctuations (Figs. 2 and 3). Station 5 had significantly greater numbers than Station 1 only. The low zooplankton density at Station 6 may be attributed to the extreme depth of the location (Table 1), which would tend to lower overall density per cubic meter. As most zooplankters are found in the euphotic zone (Pope 1973), the mean density for Station 6 would probably have been higher, had the unproductive lower depths not been included in the sample. The much greater depth at this location probably results in data more typical of the open waters of Lake Nipigon.

Zooplankton populations seemed to be more stable inside Ombabika Bay than outside¹, the latter fluctuating numerically to a greater degree from week to week (Fig. 2 and 3). This consistently greater fluctuation may be caused by a more pronounced clumping of individuals outside the bay, resulting in greater variability in the numbers encountered from day to day, as well as by greater fluctuations in the total zooplankton populations.

¹Hereafter "outside Ombabika Bay" refers to a combined mean from Stations 4, 5 and 6, while "inside Ombabika Bay" applies in the same way to Stations 1, 2 and 3.

Table 1: Mean Zooplankton densities

<u>Station</u>	<u>Mean Depth (m)</u>	<u>Mean Zooplankton Density ($\frac{no}{m^3}$)</u>
1	13.5	68,163
2	20.4	68,074
3	15.9	67,184
4	10.8	107,640
5	14.3	118,515
6	55.2	66,248

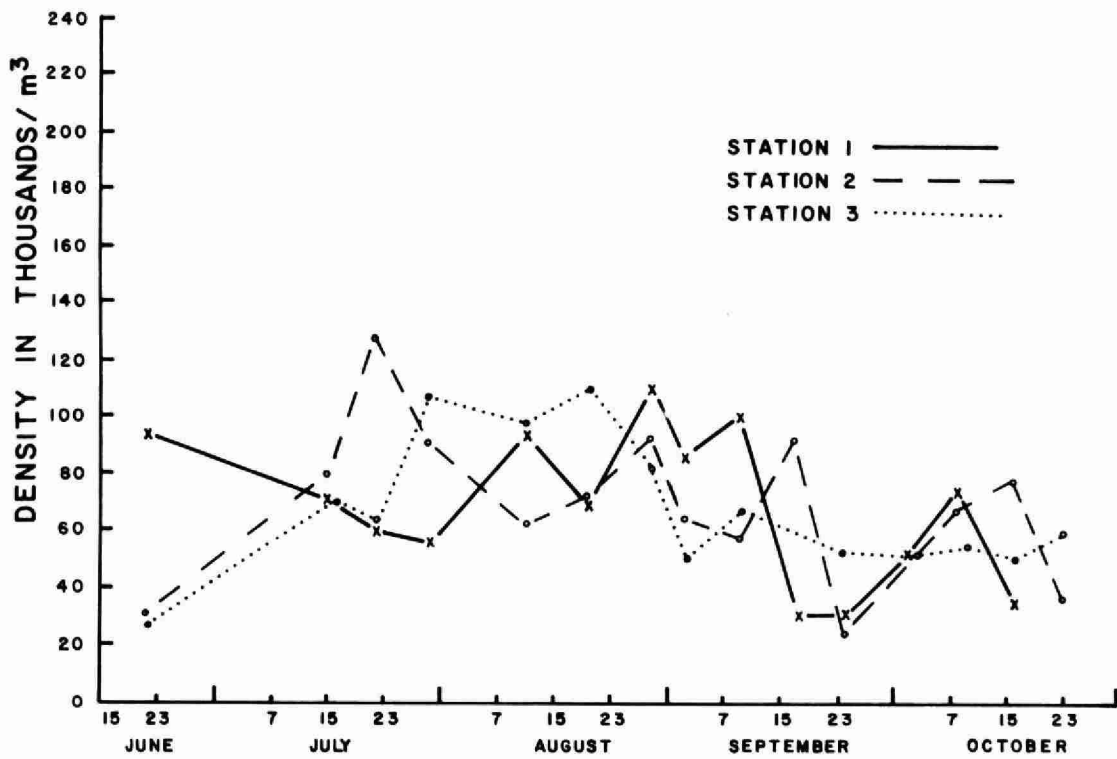


FIGURE 2 ZOOPLANKTON DENSITY - STATIONS 1, 2. AND 3.

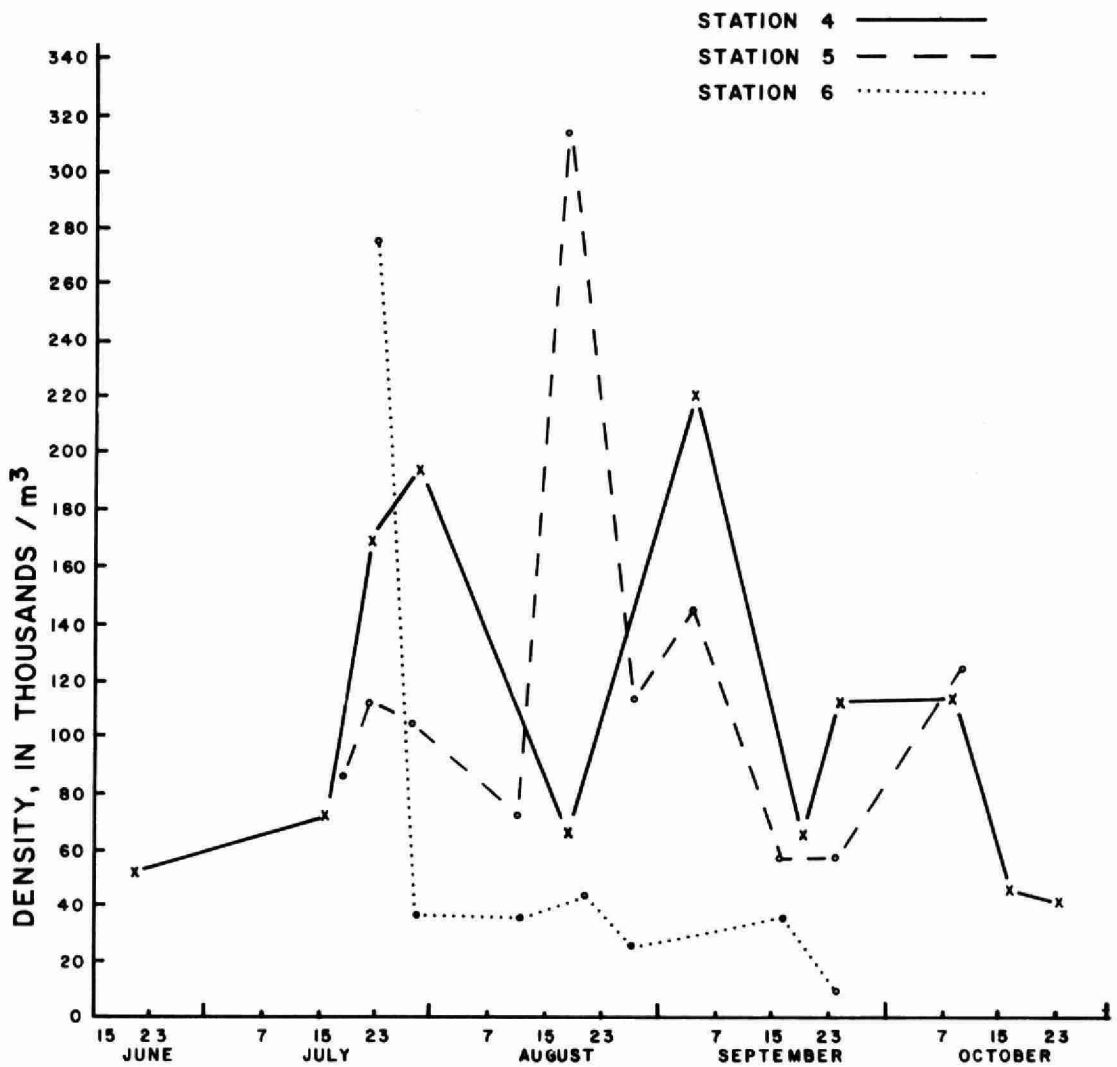


FIGURE 3 ZOOPLANKTON DENSITY-STATIONS 4, 5 AND 6.

Species Composition

A total of 21 zooplankton species were found in Lake Nipigon (Appendix 1), all included under two orders, Copepoda and Cladocera. Rotifers, very minute planktonic organisms were not included in identification or enumeration.

Copepods, consisting of both immature (naupliar and copepodid) stages and adults (calanoid and cyclopoid), were the most abundant organisms. Immature copepods consistently formed the greatest single group in all zooplankton populations, being reduced somewhat in August and September. Station 6 was found to have significantly higher numbers of nauplii and copepodids than Stations 1 and 2, and Station 4 had significantly more than Station 2.

Calanoid copepods were slightly higher in relative mean abundance outside Ombabika Bay (7.7%) than inside (6.4%) although these differences were insignificant by statistical analysis. Patalas (1972) found calanoids (especially Diaptomus sicilis and D. ashlandi) to become increasingly important with oligotrophy in the Great Lakes. Although D. sicilis was too rare to show any statistically significant trends, a three fold increase was found outside Ombabika Bay (Appendices 2-7). D. ashlandi was significantly greater in mean abundance at Station 4 as compared to Stations 1, 2 and 3. Station 5 also contained significantly more than Station 1. D. ashlandi was three times more abundant outside Ombabika Bay, being the most important calanoid in this area. D. minutus, considered a mesotrophic species in Lake Ontario (McNaught et al. 1975) was the dominant calanoid in Stations 1 and 2, (Table 2) although statistical analysis did not reveal any significant differences between stations. D. oregonensis, the dominant calanoid at Station 3, was significantly more abundant inside Ombabika Bay than outside in all station comparisons, except for Stations 3 and 5 in which differences between the two were insignificant. All other calanoids did not show any significant variation in mean abundance from station to station. Epischura lacustris, however, revealed differences in seasonal distribution, its populations peaking in June and July inside Ombabika Bay while August and September maxima had occurred at Stations 4, 5 and 6 (Appendices 2-7).

While no significant station-to-station differences were seen in any cyclopoid copepod abundances, Cyclops vernalis and Mesocyclops edax, both increasingly

common with eutrophy in the Great Lakes (Patalas 1972), were respectively five times and ten times more abundant inside Ombabika Bay, but never common enough to be adequately represented for statistical purposes.

C. bicuspidatus thomasi was the most dominant cyclopoid at all stations, being consistently found in abundance over a wide range of aquatic environments (Edmondson 1959). Population maxima of this species occurred in late summer and fall inside Ombabika Bay and in midsummer at Stations 4, 5 and 6. Tropocyclops prasinus mexicanus, a species favoring mesotrophic conditions in the Great Lakes (Patalas 1972), was five times more abundant inside Ombabika Bay, though too rare for adequate statistical representation (Appendices 2-7).

Cladocera are more abundant in eutrophic areas of the Great Lakes (Patalas 1972). In Lake Nipigon, total Cladocera were significantly more abundant at Ombabika Bay stations when compared to all stations outside the bay (Appendices 2-7). Although Diaphanosoma leuchtenbergianum is not generally considered an "indicator species" on its own (Carter 1971), it was an important component of the Cladocera of Lake Nipigon. In accordance with the total Cladoceran distribution, D. leuchtenbergianum was five times more abundant within Ombabika Bay than in Humboldt Bay and the adjacent nearshore areas of Lake Nipigon. Bosmina longirostris, a species found to be more common in the most eutrophic parts of Lakes Erie and Ontario (McNaught et al. 1975; C.C. Davis 1968), becomes extremely abundant in areas of cultural perturbation (McNaught et al. 1975). Twice as abundant inside the bay as outside (Appendices 2-7), it was significantly more abundant at Station 2 as compared to Stations 1 and 4, and Station 1 as compared to Station 4. B. longirostris was the dominant zooplankter at Station 3, second dominant at Station 2, third at Station 1, fourth at Stations 5 and 6 and did not attain dominance (<5% relative adult abundance) at Station 4 (Table 2).

Daphnia galeata mendotae, the dominant at all stations except Station 3, is a large zooplankter, heavily preyed upon by most small fish and fry, notably young trout and perch (Brooks 1969) and is common in eutrophic and mesotrophic sections of Lake Erie (Patalas, 1972). Being significantly more abundant only at Station 2 when compared to Station 6, its dominance at most locations sampled in Lake Nipigon (Table 2)

suggests little predation on the species. Rarer species, not adequately represented for statistical analysis, did show some spatial trends. Holopedium gibberum, an indicator of oligotrophic soft waters (Pejler 1965) was more common at Stations 5 and 6 than at any other station (Appendices 2-7). Chydorus sphaericus, often associated with blue-green algae blooms in eutrophic situations (Hutchinson 1967) was present, at least once, at Stations 1, 2 and 3, but was never found outside Ombabika Bay (Appendices 2-7).

Conclusions

Ombabika Bay has been shown to be somewhat different in species composition and zooplankton density from Humboldt Bay and adjacent inshore areas of Lake Nipigon. The reasons for these differences cannot be stated with complete confidence as necessary data are lacking. The nature of the zooplankton populations, however, does suggest some possibilities as to the probable causes of differences.

It is a well established fact that small fish and fry will reduce certain zooplankton populations through planktivory. The populations of larger species (>1 mm), notably Daphnia spp. are the first to decline, as a result of their greater visibility (Brooks 1969). These zooplankters (D. galeata mendotae, D. oregonensis, D. ashlandi, D. sicilis, E. lacustris, M. edax, C. bicuspidatus thomasi, C. vernalis) showed no consistent pattern of reduced abundance with respect to Ombabika Bay and Lake Nipigon. Daphnia, clearly the most preferred planktonic food source of vertebrate planktivores (Brooks 1968) did not exhibit any regular trends as to its frequency, being significantly different in abundance in only one station comparison. Thus, fish predation (or the lack of it) was most probably not a major force in shaping the different species composition of Ombabika Bay.

Cyclopoid predators, of which C. bicuspidatus thomasi was the most common, also did not exhibit significant differences in distribution, although two rare species (C. vernalis and M. edax) were more common inside Ombabika Bay. Their scarcity, however, probably created a negligible difference in predation rates. Cyclopoid predation on smaller zooplankton less than 1 mm long (Dodson 1974) must therefore not be significantly

different in either area. (Populations of certain small zooplankters inside Ombabika Bay, such as *D. leuchtenbergianum* and *B. longirostris*, when compared to stations 4, 5 and 6, do vary significantly - these differences are probably due to environmental factors other than cyclopoid predation).

As predation differences from vertebrate and cyclopoid sources seem to be insignificant, and as phytoplankton populations do not vary appreciably between stations (G. Hopkins, Ontario Ministry of the Environment, personal communication), changes in the physical and/or chemical environment are probably responsible for the differences in zooplankton characteristics inside Ombabika Bay. As mentioned previously, species common to eutrophic waters seem to exist in greater abundance inside the bay, with oligotrophic forms being reduced in frequency. At Stations 4, 5 and 6, the reverse trend appears, with oligotrophic forms outnumbering the more eutrophic species. Density of zooplankton, however, was somewhat greater in the latter location. Although the co-occurrence of seemingly more eutrophic, higher densities with predominantly oligotrophic species (and vice versa) may at first appear contradictory, zooplankton density differences were probably not of sufficient magnitude to suggest well defined dissimilarities in trophic state. The greater abundance of eutrophic zooplankters inside Ombabika Bay may in fact be related to any number of factors including basin morphometry, water temperature, turbulence and bacterial, algal, and fish populations. A more extensive interpretation of the zooplankton data than that presented here is probably precluded until these additional components of the Lake Nipigon environment are more completely understood and documented.

Table 2: Dominant zooplankton species of inshore and embayment areas of Lake Nipigon, 1975.
All zooplanktors constituting 5% or more of the mean adult population are considered dominant.

		Stations					
		1	2	3	4	5	6
Dominance							
1st	<u>D. galeata</u> 30.0%	<u>D. galeata</u> 28.9%	<u>B. longirostris</u> 24.4%	<u>D. galeata</u> 31.3%	<u>D. galeata</u> 35.1%	<u>D. galeata</u> 33.2%	
2nd	<u>D. leuchtenberg- ianum</u> 18.2%	<u>B. longirostris</u> 25.5%	<u>D. galeata</u> 22.7%	<u>D. ashlandi</u> 20.9%	<u>C. bicuspidatus</u> 15.1%	<u>C. bicuspidatus</u> 16.8%	
3rd	<u>B. longirostris</u> 16.3%	<u>D. leuchtenberg- ianum</u> 17.2%	<u>D. leuchtenberg- ianum</u> 19.2%	<u>C. bicuspidatus</u> 12.3%	<u>D. ashlandi</u> 14.0%	<u>D. ashlandi</u> 14.2%	
4th	<u>C. bicuspidatus</u> 11.4%	<u>C. bicuspidatus</u> 8.0%	<u>C. bicuspidatus</u> 9.3%	<u>D. minutus</u> 6.3%	<u>B. longirostris</u> 12.6%	<u>B. longirostris</u> 11.6%	
5th	<u>D. minutus</u> 7.2%	<u>D. minutus</u> 7.0%	<u>D. oregonensis</u> 6.4%	<u>D. sicilis</u> 5.2%	<u>D. leuchtenberg- ianum</u> 8.1%	<u>D. minutus</u> 8.6%	
6th	<u>D. oregonensis</u> 5.9%	-	<u>D. ashlandi</u> 6.1%	-	<u>D. minutus</u> 7.7%	<u>D. leuchtenberg- ianum</u> 6.0%	
7th	-	-	<u>D. minutus</u> 5.2%	-	-	<u>D. retrocurva</u> 5.2%	

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Appendix 1. Zooplankton species found in embayment and inshore areas of Lake Nipigon, 1975

Copepoda

Calanoida

Diaptomus minutus Lilljeborg

Diaptomus ashlandi Marsh

Diaptomus oregonensis Lilljeborg

Diaptomus sicilis S.A. Forbes

Epischura lacustris S.A. Forbes

Epischura nevadensis Lilljeborg

Limnocalanus macrurus Sars

Senecella calanoides Juday

Cyclopoida

Cyclops bicuspidatus thomasi S.A. Forbes

Cyclops vernalis Fischer

Mesocyclops edax S.A. Forbes

Tropocyclops prasinus mexicanus Kiefer

Cladocera

Daphnia longiremis Sars

Daphnia galeata mendotae Birge

Daphnia retrocurva Forbes

Leptodora kindtii Focke

Polyphemus pediculus Linne'

Diaphanosoma leuchtenbergianum
Fischer

Holopedium gibberum Zaddach

Chydorus sphaericus O.F. Muller

Bosmina longirostris O.F. Muller

Appendix 2. Station 1 - Relative Species Abundances (in percentages)

	June 21	15	July 22	28	11	August 20	27	3	9	September 18	24	2	8	October 16	23	Mean Abundance
Nauplii	8.5	27.7	40.1	50.1	35.2	29.2	11.3	12.5	3.9	5.1	14.1	16.2	8.8	13.0		19.7
Copepodids	66.8	43.8	35.7	24.9	24.4	38.1	50.9	42.6	51.8	59.2	58.4	68.1	67.5	61.7		49.6
Total Immature Copepods	75.3	71.5	75.8	75.0	59.6	67.3	62.2	55.1	55.7	64.3	72.5	84.3	76.3	74.7		69.3
<i>D. minutus</i>	5.1	8.4	2.7	2.2	.9	.8	3.1	3.7	1.6	.4	.8	.2	.9	.4		2.2
<i>D. ashlandi</i>	2.7	.5	0	0	.7	.3	.6	1.6	.2	0	0	.2	.4	4.1		.8
<i>D. oregonensis</i>	.3	.1	.5	.9	1.6	.3	1.9	2.7	3.7	3.7	1.5	3.1	2.4	2.4		1.8
<i>D. sicilis</i>	0	0	0	0	0	0	0	0	0	0	.4	.1	0	2.5		.2
<i>E. lacustris</i>	3.1	1.2	.1	1.5	1.0	.6	.6	.7	.3	0	.6	.1	.4	0		.7
<i>E. nevadensis</i>	0	0	.3	0	0	0	0	0	0	0	0	0	0	0		.02
<i>L. macrurus</i>	0	0	0	.1	.1	.1	0	0	0	.6	0	0	.1	.2		.08
<i>S. calanoides</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Total Calanoids	11.4	10.2	3.6	4.7	4.5	2.1	6.2	8.7	5.8	4.7	3.3	3.7	4.2	9.4		5.8
<i>C. bicuspidatus</i>	5.1	4.2	2.7	3.6	2.0	1.6	2.3	4.5	3.7	3.1	3.7	3.5	5.8	3.3		3.5
<i>C. vernalis</i>	0	0	0	0	0	0	0	0	.9	0	0	.4	.9	1.0		.2
<i>H. edax</i>	.7	0	.3	.2	.2	0	.2	0	0	0	0	0	0	.2		.1
<i>T. prasinus</i>	0	0	0	0	0	.2	.2	.8	0	.2	.4	.2	.1	0		.1
Total Cyclopoids	5.8	4.2	3.0	3.8	2.2	1.8	2.7	5.3	4.6	3.3	4.1	4.1	6.8	4.5		3.9
Total Copepods	92.5	85.9	82.4	83.7	66.3	71.2	71.1	69.1	66.1	72.3	79.9	92.1	87.3	88.6		79.0
<i>D. longiremis</i>	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0		.1
<i>D. galeata</i>	2.4	5.3	7.3	9.3	18.8	12.2	16.1	17.0	17.0	10.2	5.2	1.1	2.9	0		8.9
<i>D. retrocurva</i>	1.2	2.6	1.1	1.2	.4	.1	1.5	1.1	.9	.2	0	0	0	0		.7
<i>L. kindtii</i>	.2	0	.1	.2	0	0	0	0	.1	0	0	0	0	0		.04
<i>P. pediculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
<i>D. leuchtenbergiarum</i>	.3	4.8	5.1	4.2	11.2	14.6	6.8	10.4	10.8	5.5	3.1	1.8	4.1	1.2		5.6
<i>H. gibberum</i>	.2	0	0	0	0	0	0	0	0	0	0	0	0	0		.01
<i>C. sphaericus</i>	0	0	0	0	0	0	0	0	.2	0	0	0	0	0		.01
<i>B. longirostris</i>	2.4	1.2	4.0	1.6	3.4	1.7	4.4	2.4	4.8	11.9	11.8	4.9	5.6	10.2		5.0
Total Cladocera	7.7	14.0	17.6	16.5	33.8	28.6	28.8	39.8	33.8	27.8	20.1	7.8	12.6	11.4		20.3

Appendix 3. Station 2 - Relative Species Abundances (in percentages)

	June 21	15	July 22	28	11	August 20	27	3	9	September 17	24	9	October 16	23	Mean Abundance
Nauplii	33.0	33.5	28.7	51.6	38.4	33.8	7.6	18.4	4.6	.6	11.7	.7	3.5	3.7	19.3
Copepodids	42.5	49.3	31.8	23.1	27.6	28.3	44.2	46.3	46.3	47.0	56.3	48.5	57.8	58.1	43.4
Total Immature Copepods	75.5	82.8	60.5	74.7	66.0	62.1	51.8	64.7	50.9	47.6	68.0	49.2	61.3	61.8	62.7
<i>D. minutus</i>	9.8	3.0	5.3	4.0	2.3	.6	6.0	.5	.5	1.0	.2	.8	1.3	.8	2.6
<i>D. ashlandi</i>	1.9	.3	.8	.1	.6	.5	0	0	0	2.0	.7	.7	3.0	5.6	1.2
<i>D. oregonensis</i>	.3	.1	.9	.8	.1	0	2.9	.9	3.2	4.1	2.3	4.5	3.8	0	1.7
<i>D. sicilis</i>	0	0	0	0	.1	.1	.3	0	0	.2	0	.2	.8	0	.1
<i>E. lacustris</i>	1.1	.6	1.0	1.1	.6	.5	.4	.7	0	.2	0	.2	0	0	.5
<i>E. nevadensis</i>	0	0	.1	0	0	0	0	0	0	0	0	0	0	.1	.01
<i>L. macrurus</i>	.8	.2	.2	.1	.6	.1	0	0	0	0	0	0	.1	.1	.2
<i>S. calanoides</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	.8	.06
Total Calanoids	13.9	4.2	8.3	6.1	4.3	1.8	9.6	2.1	3.7	7.5	3.2	6.5	9.0	7.4	6.4
<i>C. bicuspidatus</i>	2.5	1.3	3.2	2.1	2.6	1.4	2.4	2.1	3.2	3.4	3.9	5.5	3.5	4.8	3.0
<i>C. vernalis</i>	0	0	0	0	.1	.1	.1	.2	0	.2	.2	.5	0	0	.1
<i>H. edax</i>	.3	0	0	0	.3	.3	0	.2	0	.2	0	.2	0	0	.1
<i>T. prasinus</i>	0	0	0	0	0	.1	.5	0	0	.3	.2	0	3	.1	.1
Total Cyclopoids	2.8	1.3	3.2	2.1	3.0	1.9	2.9	2.5	3.2	4.3	4.3	6.2	4.3	4.9	3.3
Total Copepods	92.2	88.3	72.0	82.9	73.3	65.8	64.3	69.3	57.8	59.2	75.5	61.9	74.6	74.1	72.4
<i>D. longiremis</i>	.3	.3	.1	0	.1	0	0	0	0	0	0	0	0	0	.06
<i>D. galeata</i>	.4	3.9	11.1	6.5	11.1	21.7	23.4	20.0	23.0	12.0	6.6	2.3	1.5	7.5	10.8
<i>D. retrocurva</i>	.8	2.9	4.3	.9	.1	.1	.5	0	.5	0	.2	0	0	0	.7
<i>L. kindtii</i>	.1	0	.1	.5	0	0	.2	0	.1	0	0	0	0	0	.1
<i>P. pediculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>D. leuchtenbergiarum</i>	.5	3.9	10.8	9.1	11.8	8.6	6.2	7.1	8.4	8.4	7.6	3.2	.8	2.5	6.4
<i>H. gibberum</i>	.3	0	0	0	0	0	0	0	0	0	0	0	0	0	.02
<i>C. sphaericus</i>	0	.1	0	0	0	0	0	0	0	0	0	0	0	0	.01
<i>B. longirostris</i>	5.3	.3	1.7	.1	3.3	3.6	2.8	3.5	10.0	20.5	10.1	32.9	23.3	15.6	9.5
Total Cladocera	7.7	11.4	28.1	17.1	26.4	34.0	33.1	30.6	42.0	40.9	24.5	38.4	25.6	25.6	27.5

Appendix 4. Station 3 - Relative Species Abundances (in percentages)

	June 21	15	July 22	28	11	August 19	27	3	9	September 24	2	9	October 16	23	Mean Abundance
Nauplii	74.5	37.0	70.0	38.0	32.8	27.5	14.9	10.5	2.6	5.3	7.6	.7	2.8	2.0	23.3
Copepods	12.2	40.5	16.6	30.5	32.7	39.3	43.5	46.4	52.9	51.2	43.7	57.8	61.3	63.8	42.3
Total Immature Copepods	86.7	77.5	86.6	68.5	65.5	66.8	58.4	56.9	55.5	56.5	51.3	58.5	64.1	65.8	65.5
<i>D. minutus</i>	.2	3.2	.7	4.8	2.5	2.3	1.9	1.9	1.4	.7	2.6	1.1	1.2	1.3	1.8
<i>D. ashlandi</i>	1.3	1.1	.3	2.1	1.7	1.8	1.9	1.6	.9	1.1	.7	.5	1.2	13.4	2.1
<i>D. oregonensis</i>	.1	.1	0	.5	.1	1.9	2.3	1.2	5.2	5.3	3.3	3.6	2.8	4.3	2.2
<i>D. sicilis</i>	.1	0	0	0	0	0	0	0	0	.4	.4	.2	.3	2.0	.2
<i>E. lacustris</i>	1.8	.9	.8	.4	.7	.5	.4	.2	.3	0	.2	.2	.1	.4	.5
<i>E. nevadensis</i>	0	0	.4	.1	0	0	0	0	0	0	0	0	0	0	.01
<i>L. macrurus</i>	1.8	.3	0	0	.1	0	0	0	0	.2	.2	0	0	.8	.2
<i>S. calanoides</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Calanoids	5.3	5.6	2.2	7.9	5.1	6.5	6.5	4.9	7.8	7.7	7.4	6.0	5.6	22.2	7.0
<i>C. bicuspidatus</i>	1.9	3.7	1.5	2.7	2.0	.9	4.8	1.9	1.2	4.6	4.4	6.0	6.7	2.8	3.2
<i>C. vernalis</i>	.1	0	0	0	.2	0	.2	0	.9	0	.4	1.6	0	.2	.3
<i>M. edax</i>	0	0	0	0	.3	.1	.2	.8	0	0	.2	0	0	0	.1
<i>T. prasinus</i>	0	0	0	0	0	0	0	0	0	0	.4	.2	.6	0	.1
Total Cyclopoids	2.0	3.7	1.5	2.7	2.5	1.0	5.2	2.7	2.1	4.6	5.4	7.8	7.3	3.0	3.7
Total Copepods	94.0	86.8	90.3	79.1	73.1	74.3	70.1	64.5	65.4	68.8	64.1	66.3	77.0	91.0	76.3
<i>D. longiremis</i>	0	.3	.3	0	0	0	0	0	0	0	0	0	0	0	.04
<i>D. galeata</i>	.5	3.6	6.6	4.7	12.2	13.7	11.9	19.5	15.3	12.1	3.3	1.3	.6	4.1	7.8
<i>D. retrocurva</i>	0	2.0	.1	2.5	.2	.6	1.3	.4	0	0	0	0	0	.5	.5
<i>L. kindtii</i>	.1	0	0	.2	.1	.1	0	0	.3	0	0	0	0	0	.06
<i>P. pediculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>D. leuchtenbergiarum</i>	0	7.0	.9	11.8	11.5	8.7	11.3	9.4	19.0	5.0	5.1	.7	1.5	1.6	6.6
<i>H. gibberum</i>	.4	0	0	0	0	0	0	0	0	0	0	0	0	0	.03
<i>G. sphaericus</i>	0	0	0	0	0	0	.2	0	0	0	0	.2	0	0	.03
<i>B. longirostris</i>	4.9	.4	1.7	1.6	3.1	2.6	5.3	6.2	.1	14.2	27.7	25.8	20.8	3.3	8.4
Total Cladocera	5.4	13.0	9.6	20.8	27.1	25.7	30.0	35.5	34.7	31.3	36.1	28.0	22.9	8.9	23.5

Appendix 5. Station 4 - Relative Species Abundances (in percentages)

	June 21	16	July 22	28	11	August 18	27	4	September 19	24	8	October 16	23	Mean Abundance
Nauplii	68.8	31.0	54.0	84.6	12.2	24.2	8.5	5.1	0	.2	1.3	2.4	.6	22.9
Copepods	26.4	37.7	20.2	8.1	56.6	53.7	39.8	52.7	73.5	63.1	84.6	67.6	70.6	50.3
Total Immature Copepods	95.2	68.7	74.2	92.7	68.8	82.9	48.3	57.8	73.5	63.3	85.9	70.0	71.2	73.2
<i>D. minutus</i>	.6	2.6	3.2	.9	1.9	1.3	4.1	1.7	.2	2.4	1.3	1.8	1.6	1.7
<i>D. ashlandi</i>	1.1	4.8	6.6	.7	6.3	3.1	16.3	1.8	.5	3.6	1.7	7.6	19.4	5.6
<i>D. oregonensis</i>	0	0	.6	0	.6	.2	.2	.2	2.5	1.7	1.2	1.8	2.2	.9
<i>D. sicilis</i>	0	0	0	0	.1	.1	.2	.1	1.2	.2	.9	12.2	2.8	1.4
<i>E. lacustris</i>	.4	.1	.1	0	.2	.4	.6	.4	0	.4	.3	.3	.2	.3
<i>E. nevadensis</i>	0	0	0	0	0	0	0	0	0	.1	0	0	0	.01
<i>L. macrurus</i>	.1	.1	0	.1	0	0	0	0	0	0	.1	.6	.4	.1
<i>S. calanoides</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Calanoids	2.2	7.6	10.5	1.7	9.1	5.1	21.1	3.2	4.4	8.4	5.5	24.3	26.6	10.0
<i>C. bicuspidatus</i>	2.0	15.0	11.8	.5	2.4	1.7	1.0	.8	1.6	2.5	1.3	.9	1.3	3.3
<i>C. vernalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>M. edax</i>	0	0	0	0	.1	0	0	0	0	0	0	0	0	.01
<i>T. prasinus</i>	0	0	0	0	0	.1	0	0	0	.4	0	0	0	.04
Total Cyclopoids	2.6	15.6	11.8	.5	2.5	1.8	1.0	.8	1.6	2.9	1.3	.9	1.3	3.3
Total Copepods	99.3	91.3	96.5	94.9	80.5	89.7	71.0	64.8	79.6	74.5	92.8	95.3	99.1	86.5
<i>D. longiremis</i>	.1	0	0	1.2	0	0	0	.1	0	0	0	0	0	.1
<i>D. galeata</i>	.1	2.8	0	1.4	12.8	6.0	23.5	.1	13.7	12.1	2.4	2.1	.4	8.4
<i>D. retrocurva</i>	0	1.1	.9	1.7	1.9	.1	1.6	.1	0	0	0	0	0	.6
<i>L. kindtii</i>	.1	0	.1	0	.2	.1	.2	0	0	0	0	0	0	.05
<i>P. pediculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>D. leuchtenbergiarum</i>	0	0	0	.8	2.4	1.9	1.4	2.0	4.1	3.0	.9	.8	.3	1.3
<i>H. gibberum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>G. sphaericus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>B. longirostris</i>	.4	4.8	2.5	0	2.2	2.2	2.3	2.6	2.6	10.4	3.9	1.8	.2	2.8
Total Cladocera	.7	8.7	3.5	5.1	19.5	10.3	29.0	35.2	20.4	25.5	7.2	4.7	.9	13.2

Appendix 6. Station 5 - Relative Species Abundances (in percentages)

	June 16	July 22	28	11	August 19	27	4	September 16	24	October 9	Mean Abundance
Nauplii	20.8	64.8	70.7	3.0	10.4	15.3	4.4	10.5	6.7	2.2	20.9
Copepodids	47.2	18.1	14.3	57.9	57.5	53.5	44.2	54.9	78.9	74.2	50.6
Total Immature Copepods	68.0	82.9	85.0	60.9	67.9	68.8	48.6	65.4	85.6	81.4	71.5
<i>D. minutus</i>	6.6	2.5	1.1	2.5	2.5	1.0	4.2	0	.1	1.2	2.2
<i>D. ashlandi</i>	5.5	2.5	1.4	7.6	5.1	6.1	7.6	1.3	.2	2.9	4.0
<i>D. oregonensis</i>	0	0	0	.8	.2	.4	.5	0	.2	1.8	.4
<i>D. sicilis</i>	.6	0	0	0	0	0	0	0	.4	.2	.1
<i>E. lacustris</i>	0	.1	0	1.1	.2	.7	.7	0	.1	.2	.3
<i>E. nevadensis</i>	0	0	0	0	0	0	0	0	0	0	0
<i>E. macrurus</i>	0	0	0	0	0	0	0	.2	0	0	.02
<i>S. calanoides</i>	0	0	0	0	0	0	0	0	0	0	0
Total Calanoids	2.7	5.1	2.5	12.0	8.0	8.2	13.0	1.5	1.0	6.3	7.0
<i>C. bicuspidatus</i>	13.6	4.4	5.8	7.6	1.5	1.2	4.4	2.6	.2	1.9	4.3
<i>C. vernalis</i>	0	0	0	.2	0	0	.5	0	0	0	.1
<i>H. edax</i>	0	0	0	0	.2	0	0	0	0	0	.02
<i>I. prasinus</i>	0	0	0	.2	0	0	0	0	0	0	.02
Total Cyclopoids	13.6	4.4	5.8	8.0	1.7	1.2	4.9	2.6	.2	1.9	4.4
Total Copepods	94.4	92.6	93.3	81.0	77.9	78.1	66.6	69.7	87.0	89.7	82.9
<i>D. longiremis</i>	0	0	0	0	0	0	0	0	0	0	0
<i>D. galeata</i>	.2	1.6	1.4	11.6	17.8	17.9	22.9	22.4	2.9	1.5	10.0
<i>D. retrocurva</i>	.2	2.6	1.9	2.7	.9	.8	0	0	.1	0	.9
<i>L. kindtii</i>	.1	.1	0	.9	0	0	0	0	0	0	.1
<i>P. pediculus</i>	.1	0	0	.2	0	0	0	0	0	0	.03
<i>D. leuchtenbergianum</i>	.1	.3	0	2.3	2.1	1.8	10.3	3.1	1.0	1.6	2.3
<i>H. gibberum</i>	.2	.2	.2	.2	0	0	0	0	0	0	.1
<i>C. sphaericus</i>	0	0	0	0	0	0	0	0	0	0	0
<i>B. longirostris</i>	4.7	2.6	3.2	1.1	1.3	1.4	.2	4.8	9.0	7.2	3.6
Total Cladocera	5.6	7.4	6.7	19.0	22.1	21.9	33.4	30.3	13.0	10.3	17.1

Appendix 7. Station 6 - Relative Species Abundances (in percentages)

	June 16	July 22	28	11	August 19	27	September 16	24	October 9	Mean Abundance
Nauplii		52.9	73.4	22.7	27.9	5.7	16.9	13.4		30.4
Copepodids		23.2	12.6	44.0	42.0	65.4	73.9	63.9		46.4
Total Immature Copepods		76.1	86.0	66.7	69.9	71.1	90.8	77.3		76.8
<i>D. minutus</i>		3.9	1.3	2.2	2.3	2.0	.4	1.7		2.0
<i>D. ashlandi</i>		1.8	2.7	6.2	6.0	4.6	.3	1.2		3.3
<i>D. oregonensis</i>		0	0	0	.3	.2	.1	.3		.1
<i>D. sicilis</i>		0	0	.1	0	0	.1	1.5		.2
<i>E. lacustris</i>		0	0	.2	.4	1.0	.1	.4		.3
<i>E. nevadensis</i>		0	0	0	0	0	0	0		0
<i>E. macrurus</i>		0	.1	.2	0	0	0	1.4		.2
<i>S. calanoides</i>		0	0	0	0	0	0	0		0
Total Calanoids		5.7	4.1	8.9	9.0	7.8	1.0	6.5		6.3
<i>C. bicuspidatus</i>		8.6	6.5	6.6	2.4	1.3	.5	1.2		3.9
<i>C. vernalis</i>		0	0	.2	0	0	0	0		.03
<i>H. edax</i>		0	0	0	0	0	0	0		0
<i>I. prasinus</i>		0	0	0	0	0	0	0		0
Total Cyclopoids		8.6	6.5	6.8	2.4	1.3	.5	1.2		3.9
Total Copepods		90.4	96.6	82.4	81.3	74.5	72.4	85.0		82.0
<i>D. longiremis</i>		0	0	0	0	0	0	0		0
<i>D. galeata</i>		3.8	.5	10.0	13.0	15.6	2.7	8.1		7.7
<i>D. retrocurva</i>		4.2	1.1	2.4	.3	.3	0	0		1.2
<i>L. kindtii</i>		0	.1	.7	.1	0	0	0		.1
<i>P. pediculus</i>		0	0	0	0	0	0	0		0
<i>D. leuchtenbergianum</i>		.6	.1	.5	2.2	2.6	2.2	1.7		1.4
<i>H. gibberum</i>		.3	0	.3	0	0	0	0		.1
<i>C. sphaericus</i>		0	0	0	0	0	0	0		0
<i>B. longirostris</i>		.7	1.6	3.7	3.1	2.0	2.7	5.2		2.7
Total Cladocera		9.6	3.4	17.6	18.7	20.5	7.6	15.0		13.2

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